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## **United States Patent and Trademark Office**

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First Named Inventor: Brian Y. Lim  
Title: Apparatus and Method for Fabrication of Nanostructures Using  
Multiple Prongs of Radiating Energy  
Examiner: Maria Alexandra Elve  
Art Unit: 1725  
Customer No.: 51111  
Docket No.: ATOMP001

Commissioner for Patents  
POB 1450  
Alexandria, VA 22313-1450

### **Appellants' Brief in Support of Appeal Under 37 C.F.R. § 1.191**

Dear Commissioner:

This is an appeal brief in support of an appeal from the final office action mailed August 9, 2007. The following items are included in this brief:

Real Party in Interest starts on page 2.

Related Appeals and Interferences starts on page 2.

Status of Claims starts on page 2.

Status of Amendment starts on page 2.

Summary of the Claimed Subject Matter starts on page 2.

Grounds of Rejection to Be Reviewed on Appeal starts on page 3.

Argument starts on page 3.

Claims Appendix starts on page 11.

Evidence Appendix starts on page 17.

Related Proceedings Appendix starts on page 18.

### **Real Party in Interest**

The real party in interest is Atomate Corporation, which is the assignee of record.

### **Related Appeals and Interferences**

Appellants are not aware of any related appeals or interferences.

### **Status of Claims**

Claims 1–18 and 29–55 are pending in this application.

Claims 1–18 and 29–55 are rejected and the subject of this appeal.

A claims appendix to this appeal brief contains a listing of the pending claims.

### **Status of Amendments**

On August 9, 2007, the examiner mailed a final rejection. Appellants have not requested any amendments to the claims after this final rejection.

### **Summary of the Claimed Subject Matter**

Claim 1 is an apparatus for fabricating nanostructure-based devices on a workpiece (figures 1 and 2; paragraph 16) including: a stage for supporting the workpiece, where the workpiece includes multiple dies, each die having a catalyst on it (paragraphs 18–21); a radiating-energy source, positioned above the stage to locally heat the catalyst on at least one die via simultaneously emitted multiple prongs of radiating energy (figure 1; paragraphs 19, 23, 27); and a feedstock delivery system for delivery of feedstock gas to the catalyst (figure 3; paragraphs 19, 22, and 26).

Claim 11 is where the feedstock delivery system is positionable at least in distance above the die, and in direction of gas flow toward the die (figure 2; paragraph 19).

Claim 16 is where the stage temperature-control unit cools the workpiece to a temperature in a range from an equilibrium room temperature to –250 degrees centigrade (paragraphs 22, 25, and 29).

Claim 29 is an apparatus (figures 1 and 2; paragraph 16) including: a stage, for supporting a workpiece having a plurality of work regions, where each work region will have a catalyst on it (paragraphs 18–21); a temperature control unit, coupled to the stage, to maintain the stage and the workpiece at a first temperature (paragraph 22); a radiating energy source,

above the stage, to locally heat the catalyst of a selected work region to a second temperature, above the first temperature, via multiple prongs of radiating energy (figure 1; paragraphs 19, 23, 27); and a feedstock delivery system for delivery of feedstock gas to the catalyst (figure 3; paragraphs 19, 22, and 26).

Claim 32 is where the temperature control unit cools the stage to the first temperature (paragraphs 22, 25, and 29).

Claim 37 is where an output nozzle of the feedstock delivery system is movable to a position above the stage (figure 3; paragraphs 19 and 24).

Claim 38 is where the feedstock delivery system includes a heating element to heat the feedstock gas to a third temperature before exposing the catalyst to the feedstock gas (figure 2; paragraphs 22 and 29).

Claim 50 is the apparatus including an electric field generator, having an adjustable position relative to the stage, whereby the electric field generated by the generator will influence a direction of nanostructure growth in the selected work region (paragraph 24).

### **Grounds of Rejection to Be Reviewed on Appeal**

I. A first ground of rejection to be reviewed on appeal involves whether claim 8 and 9 are under 35 U.S.C. § 112, second paragraph, unpatentable as being indefinite for failing to particularly point out and distinctly claim the subject matter which appellants regard as the invention.

II. A second ground of rejection to be reviewed on appeal involves whether claims 1–18 and 29–55 are under 35 U.S.C. § 103(a) unpatentable over U.S. patent 6,756,026 (Colbert) in view of U.S. patent 6,110,291 (Haruta) and U.S. patent application publication 2004/0087116 (Nakayama).

### **Argument**

#### ***I. Argument Against First Ground of Rejection***

Claims 8 and 9 were rejected under section 112, second paragraph, for failing to particularly point out and distinctly claim the subject matter which appellants regard as the invention. Appellants believe this rejection is improper for the reasons discussed below.

Regarding claim 8, the examiner states in her August 9, 2007 office action, “it is not clear how a set of islands of catalyst can be associated with one die. Is the die very large, are the catalyst areas scattered about?” Regarding claim 9, the examiner states, “Is the catalyst on, in or near the die(s)?”

However, one of skill in the semiconductor processing arts would understand that semiconductor fabrication involves patterning regions (e.g., islands). An entire die, or multiple dies, of a wafer can be patterned, if so desired; or, within a single die, multiple regions can be patterned, if so desired. Patterned regions within a die (or in multiple dies) can contain a catalyst to cause nanotubes to grow in these regions. Appellants believe the claims are sufficiently definite to one of skill in the art. The rejection should be withdrawn.

## ***II. Argument Against Second Ground of Rejection***

Claims 1–18 and 29–55 were rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. patent 6,756,026 (Colbert) in view of U.S. patent 6,110,291 (Haruta) and U.S. patent application publication 2004/0087116 (Nakayama). Appellants believe this rejection is improper for the reasons discussed below.

For this argument, the claims are grouped as follows:

Group II.1: Claims 1–10, 13–15, and 17–18 stand or fall together.

Group II.2: Claims 11–12 stand or fall together.

Group II.3: Claim 16 stands or falls by itself.

Group II.4: Claims 29–31, 33–36, 39–44, 47–49, and 51–55 stand or fall together.

Group II.5: Claim 32 stands or falls by itself.

Group II.6: Claim 37 stands or falls by itself.

Group II.7: Claims 38 and 45–46 stand or fall together.

Group II.8: Claim 50 stands or falls by itself.

### **Principles of Law Relating to Obviousness**

“Section 103 forbids issuance of a patent when ‘the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains.’” *KSR Int’l Co. v. Teleflex Inc.*, 127 S.Ct. 1727, 1734, 82 U.S.P.Q.2d 1385, 1391 (2007). The question of obviousness is resolved on the basis of

underlying factual determinations including (1) the scope and content of the prior art, (2) any differences between the claimed subject matter and the prior art, (3) the level of skill in the art, and (4) where in evidence, so-called secondary considerations. *Graham v. John Deere Co.*, 383 U.S. 1, 17–18, 148 U.S.P.Q. 459, 467 (1966). Secondary considerations such as commercial success, long felt but unsolved needs, failure of others, and so forth, “might be utilized to give light to the circumstances surrounding the origin of the subject matter sought to be patented.” 383 U.S. at 18, 148 U.S.P.Q. at 467. See also *KSR*, 127 S.Ct. at 1734, 82 U.S.P.Q.2d at 1391 (“While the sequence of these questions might be reordered in any particular case, the [*Graham*] factors continue to define the inquiry that controls.”).

### **Group II.1: Claims 1–10, 13–15, 17–18**

Claim 1 recites “a radiating-energy source, positioned above the stage *to locally heat the catalyst on at least one die via simultaneously emitted multiple prongs of radiating energy.*”

#### ***Prior Art Not Being Combined in a Known Way***

The examiner is not combining Colbert, Haruta, and Nakayama in a known way to obtain predictable results. There is no suggestion that Colbert, Haruta, and Nakayama should be combined. These references are very dissimilar. Colbert discusses a method of growing carbon fiber from single carbon nanotube molecular arrays. Colbert applies heat to only a growing tip of a fiber. See column 26, lines 35–38. Haruta discusses forming thin films (completely unlike carbon fibers) by using laser ablation (using multiple laser beams) of a solid target to form a gaseous precursor material (“plumes”). Nakayama discusses when manufacturing a semiconductor device, using a laser to heat and melt a semiconductor material, where a magnetic may be optionally be used during this process.

Colbert and Haruta *teach away* from each other. At column 26, lines 35–38, Colbert states that “the only heat supplied for the growth reaction should be focused at the growing tip of the fiber.” And at column 26, lines 34–36, Colbert states “it is not necessary or preferred to preheat the carbon feedstock gas, since unwanted pyrolysis at the reactor walls can be minimize thereby.” The Colbert approach discourages heating more than just a fiber tip and is completely the opposite of Haruta’s approach of laser ablating a target to form a gaseous precursor material.

Further, Nakayama is very different from either Colbert or Haruta, or both, in that the laser is directed at a semiconductor solid material in order to melt the semiconductor solid, rather

to effect a carbon fiber growth. Also, a magnetic field (which is optional) is used to affect the flow of the melted solid so the crystals in the melted solid are altered. See Nakayama, abstract and paragraph 22. It is clear that combining Nakayama with either Colbert or Haruta, or both, will not affect carbon fiber growth.

In summary, Colbert and Haruta teach away from each other. The Colbert approach discourages heating more than just a fiber tip and is completely the opposite of Haruta's approach of laser ablating a target (which is in comparison, a relatively large area) to form a gaseous precursor material. Nakayama is very different from Colbert and Haruta in that the laser is directed at a semiconductor solid material in order to melt the semiconductor solid, rather to effect carbon fiber growth.

Therefore, the prior art is not being combined in a known way to obtain predictable results. The examiner has not made a showing of obviousness. For at least this reason, claim 1 and the other claims in this group should be allowable.

### ***Combination Falls Short***

Even if Colbert were combined with Haruta and Nakayama, and there is no basis for doing this for the reason stated above, the combination will still fall short of invention as recited in the claim.

The combination of Colbert, Haruta, and Nakayama would be to apply multiple laser beams to a growing tip of a fiber. Further, there would be melting of a solid material (fiber tip) while applying a magnetic field, which will affect the melted portion resulting crystal structure when cooled down. Clearly, the combination of Colbert, Haruta, and Nakayama do not show or suggest each and every limitation each claim.

### ***Claim 1***

The cited references, considered individually or in combination, do not show or suggest locally heating the catalyst on at least one die. As discussed above, the cited references do not show or suggest heating of a die of a workpiece. In particular, Colbert heats a fiber tip, Haruta heats a solid target for ablation, and Nakayama heats a solid material to melt it. The combination of these references does not show or suggest heating using multiple prongs of radiating energy to locally heat a catalyst. Rather these references use multiple beams to ablate (i.e., to remove or destroy) or melt (to alter from a solid to a liquid state). Certainly, the claimed invention is very

different from the combination of the cited references. The invention provides a technique for enhancing the manufacturability of nanostructure-based devices not provided by the prior art.

For at least this additional reason, claim 1 and the other claims in this group should be allowable.

### **Group II.2: Claims 11–12**

Claim 11 recites “wherein the feedstock delivery system is positionable at least in distance above the die, and in direction of gas flow toward the die.”

Claim 12 recites “wherein the feedstock delivery system is positionable in X, Y, and Z directions.”

Nowhere do the prior art references show or suggest this feature of the invention. The prior art does not show or suggest a positionable feedstock delivery system.

The invention permits positioning, relative to the stage, of delivery of the feedstock gas to the catalyst. Being able to position the stage is different from being able to position the feedstock gas. When moving the stage, the stage moves relative to the radiating-energy source. In contrast, the invention as claimed allows the feedstock delivery system to be positioned independently of a position of the stage. Thus, the stage can maintain its relative position to the radiating-energy source even when the feedstock delivery system changes position.

For at least this reason, the claims in this group should be allowable.

Further, the claims in this group include limitations discussed in other groups (e.g., group II.1 above). These claims should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.

### **Group II.3: Claim 16**

Claim 16 recites “the stage temperature-control unit *cools the workpiece to a temperature in a range from an equilibrium room temperature to –250 degrees centigrade.*” Nowhere do the prior art references show or suggest this feature of the invention. A heating coil cannot be used to cool a stage, especially below the equilibrium room temperature.

For at least this reason, claim 16 should be allowable.

Further, the claim in this group includes limitations discussed in other groups (e.g., group II.1 above). This claim should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.



#### **Group II.4: Claims 29–31, 33–36, 39–44, 47–49, and 51–55**

Claim 29 recites “a temperature control unit, coupled to the stage, to maintain the stage and the workpiece at a *first temperature*.”

Claim 29 further recites “a radiating energy source, above the stage, to locally heat the catalyst of a selected work region to a *second temperature*, above the first temperature, via multiple prongs of radiating energy.”

Nowhere does the cited reference teach or suggest the recited features the invention. See arguments in group II.1. For at least this reason, claim 29 and the other claims in this group should be allowable.

Further, the combination of Colbert, Haruta, and Nakayama do not show or suggest a first temperature and a second temperature, where the second temperature is above the first temperature. For at least this additional reason, claim 29 and the other claims in this group should be allowable.

#### **Group II.5: Claim 32**

Claim 32 recites “wherein the temperature control unit cools the stage to the first temperature.” The combination of Colbert, Haruta, and Nakayama do not show or suggest cooling. A heating coil cannot be used to cool a stage. For at least this reason, claim 32 should be allowable.

Further, the claim in this group includes limitations discussed in other groups (e.g., group II.4 above). This claim should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.

#### **Group II.6: Claim 37**

Claim 37 recites “wherein an *output nozzle of the feedstock delivery system is movable to position above the stage*.” The combination of Colbert, Haruta, and Nakayama do not show or suggest an output nozzle of the feedstock delivery system that is movable. See argument in group II.2 above. For at least this reason, claim 37 should be allowable for this additional reason.

Further, the claims in this group include limitations discussed in other groups (e.g., group II.4 above). These claims should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.

### **Group II.7: Claims 38 and 45–46**

Claim 38 recites “wherein the feedstock delivery system comprises *a heating element to heat the feedstock gas to a third temperature* before exposing the catalyst to the feedstock gas.”

Claim 45 recites “wherein the *third temperature* is different from the first and second temperatures.”

Claim 46 recites “wherein the first, second, and third temperatures are set independently of each other.”

The combination of Colbert, Haruta, and Nakayama do not show or suggest a heating element to heat the feedstock gas to a third temperature. Nowhere does the prior art show or suggest first, second, and third temperatures.

For at least this reason, claim 38 and the other claims in this group should be allowable for this additional reason.

Further, the claims in this group include limitations discussed in other groups (e.g., group II.4 above). These claims should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.

### **Group II.8: Claim 50**

Claim 50 recites “an *electric field generator, having an adjustable position relative to the stage*, whereby the electric field generated by the generator will influence a direction of nanostructure growth in the selected work region.” The combination of Colbert, Haruta, and Nakayama do not show or suggest where the electric field generator has an adjustable position. With an adjustable position, angles (for example) may be changed or adjusted as desired, which will influence a direction of nanostructure growth. This feature is not provided by the prior art. Furthermore, the magnetic field, by way of a magnet, in Nakayama is not the same as an electric field of the invention.

For at least this reason, claim 50 should be allowable.

Further, the claim in this group includes limitations discussed in other groups (e.g., group II.4 above). This claim should be allowable for at least the reasons discussed in this group and for the additional reasons discussed in the other groups.

## **Conclusion**

For the above reasons, appellants submit that the examiner's rejections of the claims should be withdrawn, and reversal of the examiner's decision is respectfully requested.

Respectfully submitted,

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Attachments: Claims Appendix

Evidence Appendix

Related Proceedings Appendix

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## Claims Appendix

1. An apparatus for fabricating nanostructure-based devices on a workpiece comprising:  
a stage for supporting the workpiece, wherein the workpiece includes multiple dies, each die having a catalyst on it;  
a radiating-energy source, positioned above the stage to locally heat the catalyst on at least one die via simultaneously emitted multiple prongs of radiating energy; and  
a feedstock delivery system for delivery of feedstock gas to the catalyst.
2. The apparatus of claim 1 wherein the radiating-energy source is a laser source, and the multiple prongs are multiple laser beams.
3. The apparatus of claim 2 wherein the multiple laser beams comprise a type selected from the set consisting of YAG, excimer, CO<sub>2</sub>, argon, helium-neon, ruby, neodymium glass, semiconductor, and free electron.
4. The apparatus of claim 2 wherein the multiple laser beams originate from a single laser split by at least one beam splitter.
5. The apparatus of claim 2 wherein the multiple laser beams comprise at least ten laser beams.
6. The apparatus of claim 1 wherein the radiating-energy source includes at least one of a focused acoustic, focused radio frequency (RF), focused infrared (IR), or focused microwave source.
7. The apparatus of claim 1 wherein the apparatus is configured to permit the multiple prongs to be positioned and aligned so that all catalyst throughout the die that are desired for seeding growth are irradiated.

8. The apparatus of claim 1 wherein the apparatus is configured to permit the multiple prongs to be positioned and aligned so that all catalyst throughout die that are desired for seeding growth are irradiated in multiple irradiating periods, in which a set of islands of catalyst irradiated in a first irradiating period is not identical to a set of islands of catalyst irradiated in a second irradiating period.

9. The apparatus of claim 1 wherein the apparatus is configured to permit the multiple prongs to be positioned and aligned so that all catalyst throughout die that are desired for seeding growth are irradiated in multiple irradiating periods, in which each period of said multiple periods uses a different set of fabrication parameters.

10. The apparatus of claim 1 wherein the radiating-energy source includes a beam splitter, wherein a plurality of the multiple prongs are produced by the beam splitter from beams that number fewer than the plurality.

11. The apparatus of claim 1 wherein the feedstock delivery system is positionable at least in distance above the die, and in direction of gas flow toward the die.

12. The apparatus of claim 1 wherein the feedstock delivery system is positionable in X, Y, and Z directions.

13. The apparatus of claim 1 wherein the stage can be is configured to be capable of being translated or rotated relative to the radiating-energy source, whereby any die of the workpiece is capable of being positioned for exposure to said radiating-energy source.

14. The apparatus of claim 1 wherein the apparatus is configured to permit at least a portion of said radiating-energy source to be translated or rotated relative to the stage, whereby the multiple prongs are capable of being selectively positioned for radiating energy onto any given die of the workpiece.

15. The apparatus of claim 1 wherein the stage includes a stage temperature-control unit for helping to control a temperature of the workpiece.

16. The apparatus of claim 15 wherein the stage temperature-control unit cools the workpiece to a temperature in a range from an equilibrium room temperature to  $-250$  degrees centigrade.

17. The apparatus of claim 15 wherein the stage temperature-control unit heats the workpiece to a temperature in a range from an equilibrium room temperature to  $1200$  degrees centigrade.

18. The apparatus of claim 1 wherein the apparatus is for fabricating carbon nanostructure-based devices.

29. An apparatus comprising:  
a stage, for supporting a workpiece having a plurality of work regions, wherein each work region will have a catalyst on it;  
a temperature control unit, coupled to the stage, to maintain the stage and the workpiece at a first temperature;  
a radiating energy source, above the stage, to locally heat the catalyst of a selected work region to a second temperature, above the first temperature, via multiple prongs of radiating energy; and  
a feedstock delivery system for delivery of feedstock gas to the catalyst.

30. The apparatus of claim 29 wherein the multiple prongs of radiating energy are simultaneously emitted by the radiating energy source.

31. The apparatus of claim 29 wherein the temperature control unit heats the stage to the first temperature.

32. The apparatus of claim 29 wherein the temperature control unit cools the stage to the first temperature.

33. The apparatus of claim 29 wherein the selected work region will comprise a plurality of nanostructure devices.

34. The apparatus of claim 29 wherein the radiating energy source comprises focused infrared radiation.

35. The apparatus of claim 29 wherein the radiating energy source comprises a laser.

36. The apparatus of claim 29 further comprising:  
a temperature sensor, coupled to the stage, to monitor a temperature of the workpiece.

37. The apparatus of claim 29 wherein an output nozzle of the feedstock delivery system is movable to position above the stage.

38. The apparatus of claim 29 wherein the feedstock delivery system comprises a heating element to heat the feedstock gas to a third temperature before exposing the catalyst to the feedstock gas.

39. The apparatus of claim 29 wherein work regions other than the selected work region are at the first temperature.

40. The apparatus of claim 29 wherein in the selected work region, a plurality of nanotube structures will be formed.

41. The apparatus of claim 40 wherein in work regions other than the selected work region, nanotube structures are not formed.

42. The apparatus of claim 29 wherein in the selected work region, a plurality of nanowire structures will be formed.

43. The apparatus of claim 42 wherein in work regions other than the selected work region, nanowire structures are not formed.

44. The apparatus of claim 29 wherein the first and second temperatures are set independently of each other.

45. The apparatus of claim 38 wherein the third temperature is different from the first and second temperatures.

46. The apparatus of claim 38 wherein the first, second, and third temperatures are set independently of each other.

47. The apparatus of claim 29 wherein there are more than ten prongs of radiating energy.

48. The apparatus of claim 29 wherein there are more than fifty prongs of radiating energy.

49. The apparatus of claim 29 wherein there are more than one hundred prongs of radiating energy.

50. The apparatus of claim 29 further comprising:  
an electric field generator, having an adjustable position relative to the stage, whereby the electric field generated by the generator will influence a direction of nanostructure growth in the selected work region.

51. The apparatus of claim 29 further comprising:



a magnetic field generator, having an adjustable position relative to the stage, whereby the magnetic field generated by the generator will influence a direction of nanostructure growth in the selected work region.

52. The apparatus of claim 29 wherein the multiple prongs of radiating energy are parallel to each other.

53. The apparatus of claim 29 wherein the multiple prongs of radiating energy are not parallel to each other.

54. The apparatus of claim 52 wherein the multiple prongs of radiating energy are perpendicular to a surface of the selected work region.

55. The apparatus of claim 52 wherein the multiple prongs of radiating energy are at an angle other than perpendicular to a surface of the selected work region.

## **Evidence Appendix**

None

## **Related Proceedings Appendix**

None